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ABSTRACT

Part of the Understanding Our Environment project that is designed to engage students in investigating specific environmental problems through concrete activities and direct experience, this unit places Earth in the context of its environment-the Universe-then focuses on Earth as seen from satellites. Students analyze patterns formed by the locations of volcanoes and earthquakes around the world and discover the boundaries of tectonic plates. Students begin by creating a tour of space, from quasars to Earth, and end with a tour of the Earth's biomes. The objectives include: understanding that Earth is part of a larger environment that creates and influences conditions on Earth, understanding the role of the Earth's interior in influencing Earth's surface environment, considering the variety and significance of the Earth's surface features, discussing conditions that make life possible on Earth, and learning about the natural regions of the Earth. (JRH)

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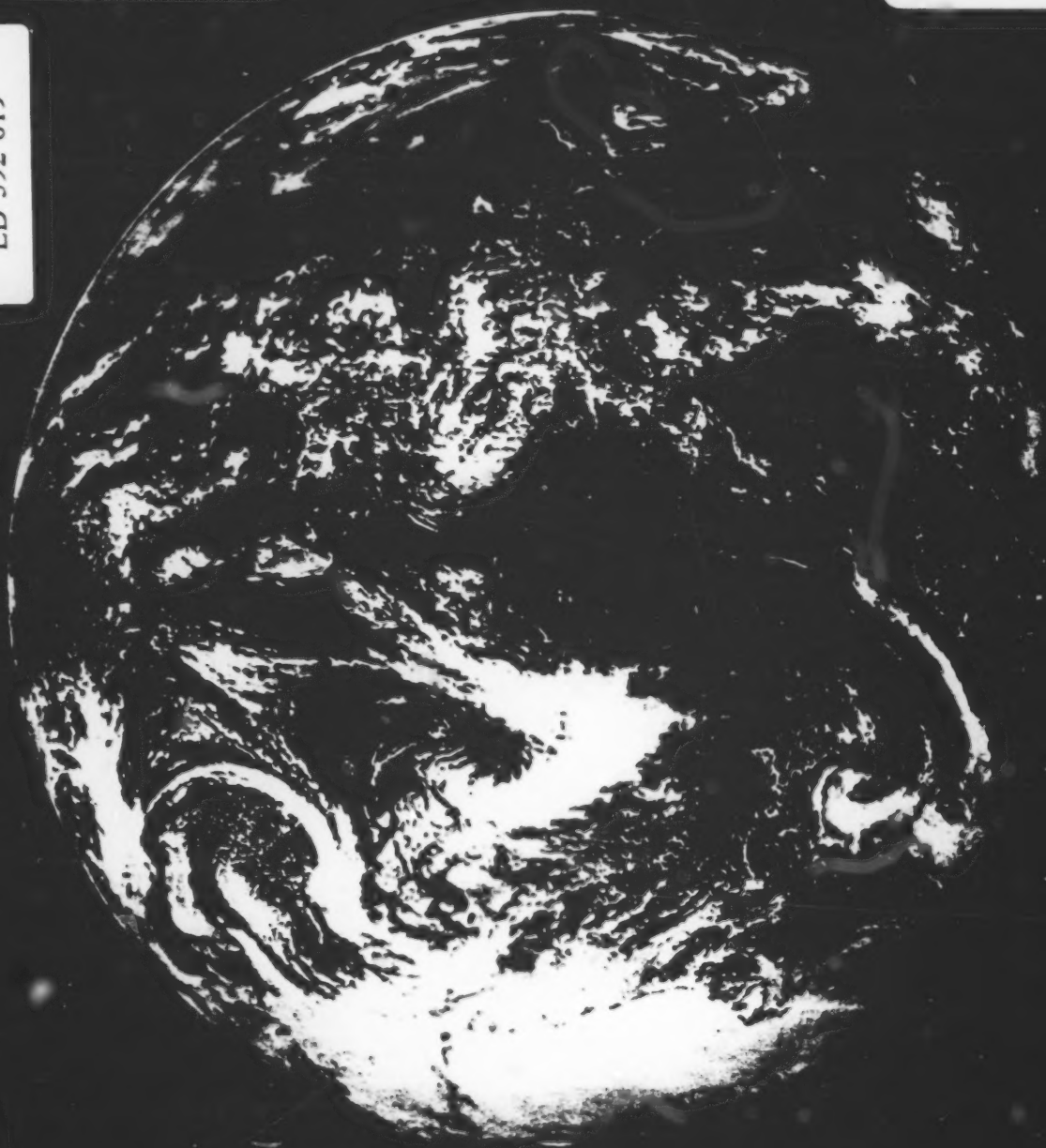

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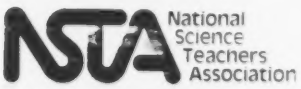

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PLANET

Jeffrey C. Callister

with contributions from

Janet Wert Crampton
M. Sheila Marshall
Irwin L. Slesnick

This publication is dedicated to Dr. Alan L. McClelland for his many years of devoted work at DuPont, in the government, and in the community to develop and educate people of all ages in mathematics, engineering, and chemistry. His commitment to advancing the understanding of the sciences has influenced thousands of lives and careers around the world.

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Portions of this material are based upon *Understanding Our Environment,* DuPont/Conoco, Birmingham, England, 1991. Substantial new material has been added.

Envelope contents for this unit:

Transparency	*Forces at Work*, plate tectonics
Poster	*The Fractured Face of Earth* and *Living on the Edge,* National Geographic Society
Lists	Volcanoes of Note Table of Earthquakes

Cover: Photograph of Earth from space showing Africa and the Arabian peninsula. Courtesy of the National Aeronautic and Space Administration (NASA).

Jeff C. Callister is an Earth science teacher at the Newburgh Free Academy, Newburgh, New York.

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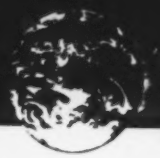

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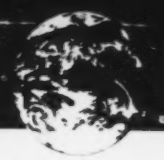
PLANET UNIT SUMMARY



This unit first places Earth in the context of its environment—the Universe—then focuses on Earth as seen from satellites. Students analyze patterns formed by the locations of volcanoes and earthquakes around the world and discover the boundaries of tectonic plates. Discussion of what makes life possible on Earth prepares students for a closer look at Earth as our own environment. For the project, students create a tour of space, from quasars to Earth, and conclude the unit with a tour of Earth's biomes.

Objectives

- Understand that Earth is part of a larger environment that creates and influences conditions on Earth.
- Understand the role of Earth's interior in influencing Earth's surface environment.
- Consider the variety and significance of Earth's surface features.
- Discuss conditions that make life possible on Earth.
- Learn about the natural regions of Earth.

What Is Earth's Space Environment?

Students may think of environment as their immediate surroundings, their school and community, for example, or familiar plants and animals, water in a stream, fog in the air. They may not have considered how far their environment actually extends.

The units in Understanding Our Environment help students explore their environment on Earth. Before exploring Earth, students learn about Earth's own environment, the Universe.

Suggested Resources

Earth in Space, a popular magazine of Earth and space sciences published by the American Geophysical Union, 2000 Florida Avenue NW, Washington, DC 20009.
Telephone: 1-800-966-2481.
Scientific American, October 1994 (Vol. 271, No. 4), special issue "Life in the Universe."

How Does the Universe Look?

In the Universe, astronomers see stars, galaxies, and groups of galaxies. A thin gas occupies the surrounding space. New data from telescopes and satellites suggest that planetary systems like the Solar System may exist.

The Universe is mostly empty space. Galaxies are very far apart. The molecules, atoms, and ions in the intergalactic gas are also very far apart.

The most distant objects in the Universe that can be detected are quasars (quasi-stellar objects). They are the cores of very active galaxies and the most energetic, luminous objects in space. Their radiation is especially strong in infrared, X-ray, and radio wavelengths.

Many astronomers think the Universe originated about 15 billion years ago in a single explosion, the Big Bang. The universe has been expanding since then.

Suggested Resources

Gore, Rick. (1983, June). The Once and Future Universe. *National Geographic, 163* (6), 704–749.
Smith, Bradford. (1994, January). New Eyes of the Universe. *National Geographic, 185* (1), 2–41.

Activity: Simulating the Expanding Universe

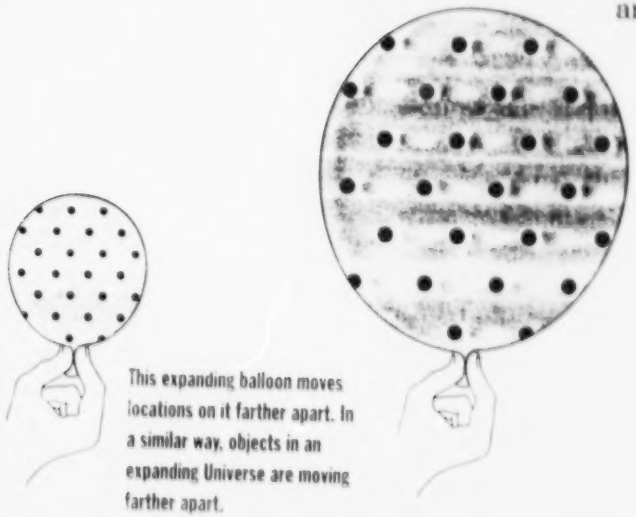
Give small groups of students one round balloon, one rubber band to close the balloon, and one marking pen each. The balloon represents the early Universe. Have students inflate the balloon halfway, and measure and record its circumference. Tell students to use the pen to draw small dots about one centimeter apart on the balloon, then fully inflate the balloon.

Students measure and record the balloon's new circumference, and the distances between dots that originally were 1, 2, 3, 4, 5, and 6 cm apart. Students should make a table to record their measurements.

How did distance between dots change? What is the pattern of change for the different separations? What does the change represent? How is the expanding balloon like the expanding Universe? How is it different? Have groups compare their measurements and discuss what might have caused differences.

Extension: The Farthest Objects

Some quasars are about 15 billion light-years away, at the "edge" of the Universe. (When you look at a quasar, you see the object as it appeared 15 billion years ago, shortly after the Big Bang.) Have students calculate the distance in kilometers to a quasar. Light travels 299,792 km/second, and a light-year is the distance light travels in one year.



This expanding balloon moves locations on it farther apart. In a similar way, objects in an expanding Universe are moving farther apart.

Project 1: Tour of Earth's Space Environment

Students research the Universe and assemble a display to simulate the return of a spaceship to Earth from a quasar at the "edge" of the Universe. They gather pictures and diagrams of objects in the Universe and arrange the pictures on classroom walls or in a school hall. They write short descriptions to place beside the pictures. The display should start at the quasar and end at your school.

The Path Through Space

The space voyage home is through the thin gas and dust in the space around galaxies. The voyagers pass quasars, black holes, different kinds of stars in different kinds of galaxies, through the Local Group of galaxies, to the Milky Way's spiral galaxy, which contains the Sun and its Solar System.

In the Solar System, the voyagers go through the Oort cloud, where comets may reside. They pass the outer planets (Pluto, Neptune, Uranus, Saturn, Jupiter), transit the Asteroid Belt, swing around the Sun, pass Mercury and Venus and swing past Earth and around Mars (the four inner planets), and finally orbit the Moon before approaching Earth.

The spaceship speeds toward Earth, through the radiation belts and past artificial satellites carrying instruments for studying the Universe, Earth's environment in space, and Earth's atmosphere, hydrosphere, biosphere, and lithosphere. The voyagers can see continents, islands, oceans, mountains, lakes, rivers, glaciers, deserts, and large circular areas on Earth's surface. They find home using satellite images, road maps, topographic maps, and maps of their state, county, city, and neighborhood.

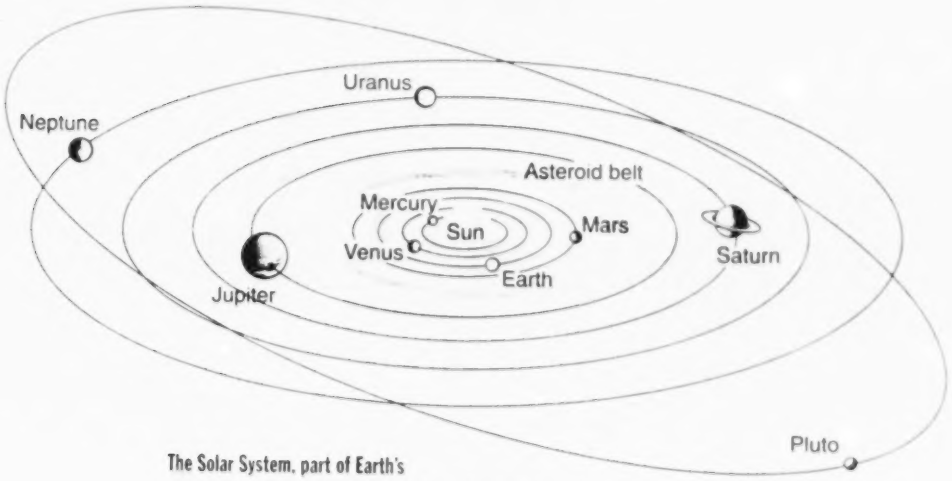
Research on Earth's Space Environment

Each picture in the Universe display will need an explanation mounted beside it. Students can research the pictures in articles, videos, films, film strips, computer programs, CD-ROMs, and other materials about astronomy

and space science. Specimens of meteorites and tektites may be available. (Tektites are small pieces of nonvolcanic glass found in groups around the world, probably formed from rocks melted by meteorite impact.)

Invite astronomers and Earth science teachers at local high schools and colleges to discuss astronomical research with the class. Locate the nearest amateur astronomy group and ask a representative to talk to the class. Different groups specialize in comets, meteors, asteroids, variable stars, or other celestial objects.

Visit the planetarium in your school district or at a local museum or park, or use an inflatable planetarium to locate celestial objects and study the Solar System.



The Solar System, part of Earth's space environment. Earth is third planet from the Sun.

Teaching Strategies

You may wish to have students work in groups researching different celestial objects like quasars, galaxies, stars, gas and dust, and the Solar System. You could divide the Solar System into inner and outer planets with their satellites, comets, asteroids, and the Sun. You will also need groups to handle the maps of Earth, Western Hemisphere, United States, your state, county, and locality. Include a picture of the school.

The project could be a cooperative teaching venture with the science, mathematics, language, art, technical, and music teachers. Students could research space "music" to broadcast for the display.

Suggest that students make a detailed display of the Solar System. Students may enjoy developing models of the Solar System and its planets and their satellites.

In the classroom or in a central place in the school, display a globe of Earth (large inflatable models can be suspended from the ceiling). You might add satellites to the model.

You may wish to have students pretend to travel in space exploring the Universe as they would a forest or cave on Earth. As an extension, students may research the environment in a spaceship.

Extension: Conducted Tours

When the display is up, have the class form groups of tour guides. The guide groups may be made of a member from each of the groups that put up the display so different students talk about different parts of the display. Give tours to other classes, on Family Night, or as a PTA program. Invite the local amateur astronomy group or community groups like the Chamber of Commerce for a tour.

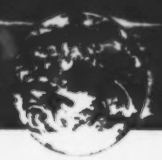
Suggested Resources

Black, David C. (1991, January). Worlds Around Other Stars. *Scientific American, 264* (1), 76–82.

Courvoisier, Thierry J.-L., and Robson, E. Ian. (1991, June). The Quasar 3C 273. *Scientific American, 264* (6), 50–67.

Sagdeev, Roald Z., and Kennel, Charles F. (1991, April). Collisionless Shock Waves [Earth's space environment]. *Scientific American, 264* (4), 106–113.

Smith, Bradford A. (1990, August). Voyage of the Century [Views of the Solar System from Voyager 1 and Voyager 2]. *National Geographic, 178* (2), 48–65.



Collisions with Earth

In the activity "What Happens When Giant Meteors Collide with Earth?" (see Activity Sheet), students investigate conditions on Earth when the largest known impact craters were formed, then theorize about the effects of these impacts on Earth's environment. (Note: A meteor that survives to hit the Earth's surface is called a meteorite.)

Implications for Mass Extinctions

Some virtual overnight (in a geological time sense) extinctions of large groups of organisms may have been caused by several effects of the impact of a giant meteorite. The Alvarez theory, for example, links the extinction of many species at the end of the Cretaceous Period to the impact of an extraterrestrial object. Possible effects of past major impacts include:

1. Worldwide dust clouds persisted for months, blotting out the Sun and cutting off photosynthesis. Plants could survive with stored food, seeds, and spores, but large herbivorous animals and carnivorous animals could not.
2. Impact-triggered global wildfires decreased oxygen and increased carbon dioxide in the atmosphere.
3. In the Yucatan impact, trillions of tons of sulfur oxides were released into the atmosphere, creating conditions for worldwide acid precipitation of battery-acid strength. Heavy rains likely occurred until the heat of the impact dissipated and normal solar evaporation of ocean water resumed.
4. The entrance of a giant meteor into the atmosphere and the resulting explosion may have shredded the ozone layer, exposing Earth to unfiltered ultraviolet radiation.
5. Impacts may have caused significant changes in climate, with rainfall and water levels changed.
6. Giant impacts may have ruptured Earth's crust, causing huge volumes of lava to flow onto Earth's surface.

What Happens When Giant Meteors Collide with Earth?

Evidence suggests that during the past three billion years there have been about 1,000 collisions between Earth and asteroid- or comet-like bodies, producing impact craters greater than 1 kilometer in diameter. This rate amounts to about three major impacts every one million years.

In the past 600 million years, at least five such bodies have produced craters that are 100 kilometers or more in diameter. Relative to Earth, giant meteors travel at great speed and hit Earth with tremendous force. The energy of collision is so great that it may be compared to that of hundreds of millions of hydrogen bombs going off at once. The energy released by such an impact can vaporize and melt much of the countryside.

What effects have these impacts had on Earth's environment? We consider this question in the following activity.

Meteorite Craters

The following table lists the five largest known impacts of the past 600 million years. The entries give crater size, location, and age.

Meteor Crater, Arizona, is a young impact crater, formed about 50,000 years ago. Erosion has not yet destroyed the crater's features. It is almost 1.5 km in diameter and about 180 m deep. The rim stands about 45 m above the surrounding plateau.

1. Use the geological time scale to determine in what geologic period each of the giant meteorites made its crater on Earth. What changes were happening on Earth at the time each impact occurred? You may already know what was going on 65,000,000 years ago, when the Mesozoic Era was ending and the Cenozoic Era was beginning.

2. Find out what you can about what scientists know was happening on Earth at the time of each giant impact, and write a short description.

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Earth's Largest Known Impact Craters

Diameter	Location	Age (in Years)
300 km	Gondwana (ancient continent, parts now in Africa, Australia, South America)	250,000,000
200 km	Yucatan, Mexico	65,000,000
150 km	South Australia	593,000,000
100 km	Shanghai, China (Taihu Lake)	365,000,000
100 km	Popigai, Russia	39,000,000

Analysis

The divisions of the geological time scale correspond to sudden changes in the environment. Think about the following questions. Then discuss your ideas in groups.

1. What temperature changes might occur at the time and place of impact?
2. How might a giant meteorite impact affect the air? the weather? the climate? the ozone layer?
3. How might oxygen and carbon dioxide levels in the air be affected by an impact?
4. How long might it take dust in the air to settle following an impact?
5. Where are the materials that were blasted out of the craters?
6. How did these impacts change the rocks that were thrown out of the craters and those that remained in the ground at the impact sites?
7. How might the impacts have affected the oceans? the waves? sea level?
8. What direct and indirect effects might there be on living things: large animals, small animals, plants, and plankton?
9. If we knew a giant meteoroid were on its way to Earth, how would we protect ourselves and other life forms?

Geological Time Scale

Era	Period	Millions of years ago
Cenozoic	Quaternary	1.6
	Tertiary	66.4
Mesozoic	Cretaceous	144
	Jurrassic	208
	Triassic	245
Paleozoic	Permian	286
	Carboniferous: Pennsylvanian	320
	Carboniferous: Mississippian	360
	Devonian	408
	Silurian	438
	Ordovician	505
	Cambrian	570
Precambrian		

Epoch	Millions of years ago
Holocene	0.01
Pleistocene	1.6
Pliocene	5.3
Miocene	23.7
Oligocene	36.6
Eocene	57.8
Paleocene	66.4

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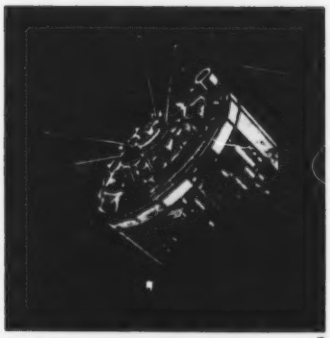
Earth Seen from Space



Satellites provide important data on Earth's weather systems, geology, biology, and population.

Remote-sensing images are not photographs, but are generated from different wavelengths of light reflected to a satellite from different materials on Earth. The colors may be computer-enhanced, using colors selected for a specific purpose.

Students will learn about satellite imagery and what it can tell us about Earth, its geology, geography, and biomes. Post the three satellite images (from the envelope) on a wall, so students can examine them closely. Distribute the Activity Sheet "What Can Satellites Tell Us About Environments on Earth?"

Satellite Images

Begin by examining the satellite images "North and South America" and "North America." Note that one image uses natural-looking colors and the other does not. Ask students to compare the detail of land forms appearing in the two images of North America. These differences reflect the differences in scale. You may wish to ask students to calculate and compare the scales of the two images.

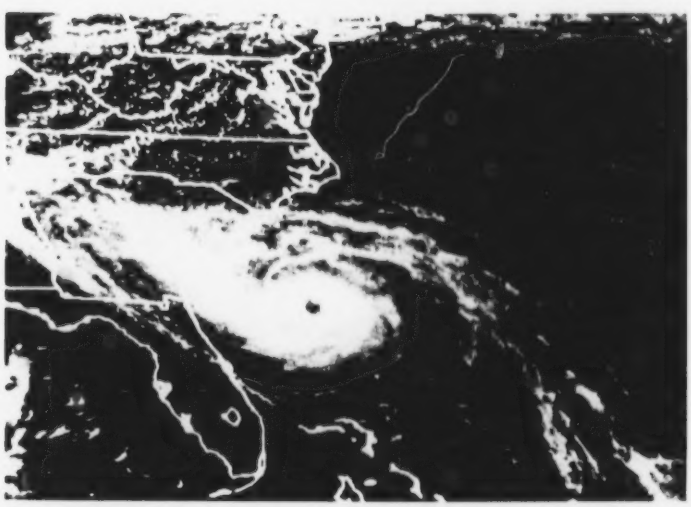


Image of Hurricane Hugo in visible light, September 21, 1989, just before it slammed into the South Carolina coast. Using images like this, forecasters were able to track the storm and predict landfall so people had time to evacuate the area.

Clouds cover much of Earth most of the time, and satellite images reveal this, as these two images and the cover of this unit show. The third image, "The Living Earth," is a cloudless mosaic, produced by selecting cloud-free frames from a large number of satellite images. Colors were selected to make the image look natural.

Let students discover how Earth's surface varies, from the whites of polar ice, the blues of liquid water, the green areas of the tropical forests to the browns of the African and Asian deserts. Point out prominent topographic features.

Conclude by discussing what satellite imagery tells us about Earth's environment and how it can be used to track changes. Remote-sensing weather images are an important information source. The cover of the Air unit shows a color-enhanced infrared image of Hurricane Hugo, with colors representing different temperature ranges.

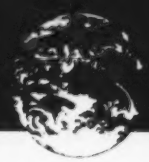
Major Terrestrial Biomes

- Tundra
- Tropical forest
- Taiga (coniferous forest)
- Grassland
- Temperate deciduous forest
- Desert

Suggested Resources

Earth System Science: A Program for Global Change. (1986). Washington, DC: National Aeronautics and Space Administration, Earth System Sciences Committee, NASA Advisory Council.

Evans, Diane L., Stofan, Ellen R., Jones, Thomas D., and Godwin, Linda M. (1994, December). Earth from Sky. *Scientific American, 271* (6), 70–75.



What Can Satellites Tell Us About Environments on Earth?

Look at the mosaic satellite image "The Living Earth," which is on display in your classroom. This remote-sensing image was taken by instruments aboard a satellite high above Earth. The picture is made up of many different images that have been carefully fitted together to give a highly detailed view with no clouds hiding the surface features.

Surface Features of Earth

Examine the satellite images of Earth, those of North and South America, also on display, and the image on the cover of this unit. Can you find vegetation, desert, water bodies, and mountain ranges? Describe what you can tell about the following:

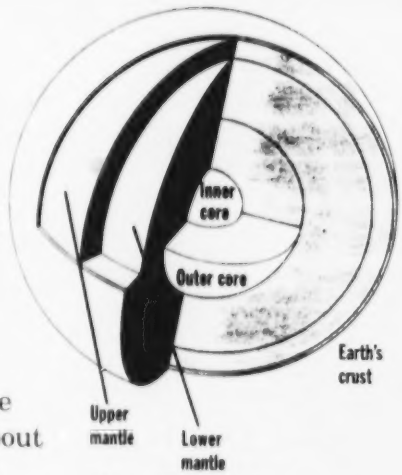
1. Mountains and plains
2. River systems and their drainage patterns
3. Oceans and major seas
4. Continents and major islands
5. Ice-covered areas
6. Vegetation
7. Terrestrial biomes
8. Weather systems

Analysis

1. What can we learn from satellite images of Earth?
2. How might satellite images show evidence of human modification of the environment?
3. What kinds of changes might be revealed by a series of satellite images taken over a period of time?

Earth's Interior

Students will use colored pencils to color in "A Slice Through Earth" as indicated on the Activity Sheet and then label the names of the zones. Help students fill in their copies, using the information below. Or make a transparency and ask students to direct you in filling it in. Distribute the Activity Sheets "What Do We Know About Earth's Interior?" and "A Slice Through Earth."



Zones of Earth's interior.

Discussion

Conduct a discussion about Earth's interior using the questions on the Activity Sheet "What Do We Know About Earth's Interior?" Review facts and concepts about the structure of Earth's interior.

Respond to student curiosity about how scientists pieced this model together by citing the following evidence:

- Drill holes and mining (at relatively shallow levels)
- Studies of seismic waves (somewhat analogous to X-rays)
- Gravity surveys
- Magnetic surveys
- Heat-flow studies
- Studies of iron-nickel meteorites, which are thought to resemble Earth's core, and rocky meteorites

To help students understand the depth and thickness of each layer in Earth's interior, draw an analogy with a car driving down the highway at 60 miles per hour (about 97 km per hour). Students could drive through the thickest part of the crust in 30 minutes, but would not reach Earth's center for two and a half days with constant driving and no stops. Remind students how far it is to Earth's center. Have them look at a U.S. map and find two cities roughly that distance apart.

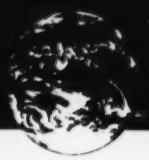
Selected Answers to "What Do We Know About Earth's Interior?"

2. The deepest drill hole is in eastern Russia (former U.S.S.R.) on the Kola Peninsula and is about 12 km deep.
3. The deepest mine is a gold mine in South Africa and is about 4 km deep.
5. Earth's radius (or distance from the surface to the center) is 6,370 km (3,956 miles).
6. We can drill into Earth only as far as 0.2% of its radius.

Suggested Resources

Callister, Jeffrey C., and Stroud, Sharon, editors. (1993). *Earth at Hand—A Collection of Articles from NSTA Journals*. Arlington, VA: National Science Teachers Association.

Monastersky, Richard. (1989, October 21). Inner Space. *Science News, 136* (17), 266–268. About the deepest drill hole.



What Do We Know About Earth's Interior?

Complete the Activity Sheet "A Slice Through Earth." Use colored pencils to color in the diagram as indicated and label the names of the zones.

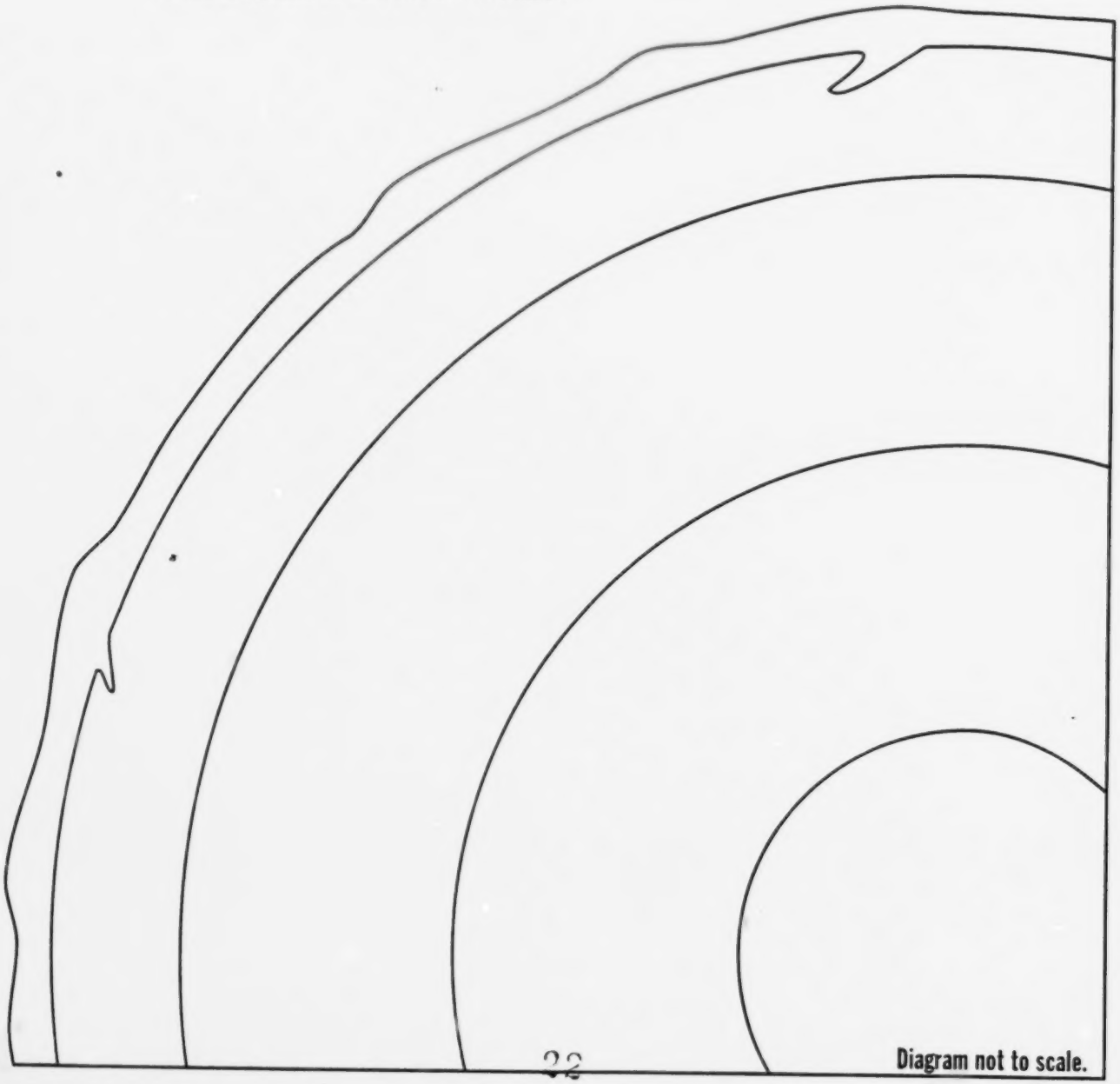
Questions

After you have discussed Earth's interior with your class, find out what you can about the the following and give your comments:

1. What is inside Earth?
2. How deep is the longest drill hole?
3. How deep is the deepest mine?
4. In which of Earth's zones are the deepest mines and drill holes found?
5. How far is it to Earth's center?
6. Express the distance that we can drill into Earth as a percentage of Earth's radius (distance to Earth's center).
7. Why do you think we have not drilled or mined deeper into Earth?
8. How do we know what Earth's interior is like below the deepest drill holes? Name some methods used to obtain this information.
9. How do you think the heat in Earth's interior affects our environment at Earth's surface?

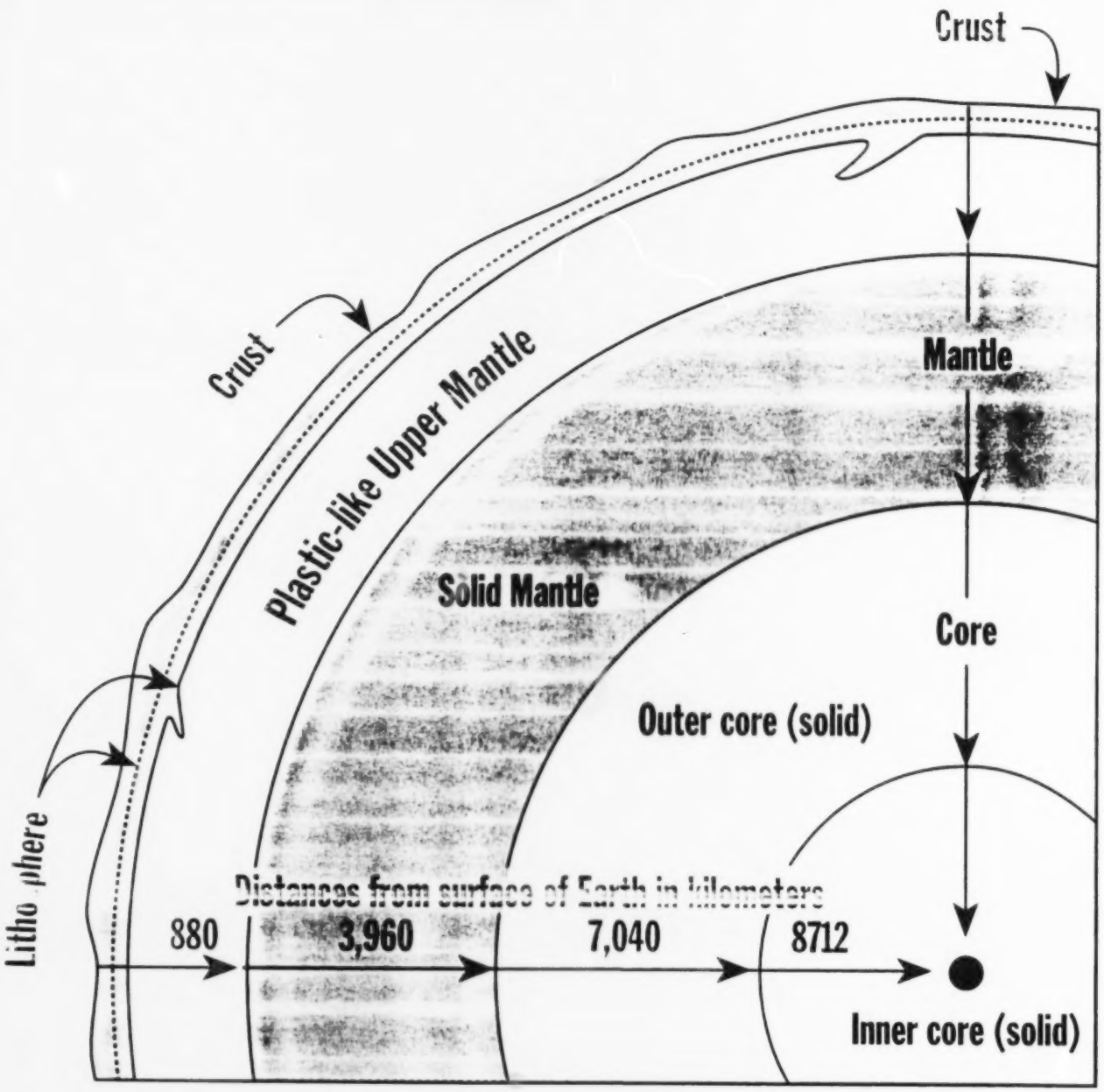
A Slice Through Earth

Write the names of the zones on the diagram. Use colored pencils to color in the diagram. Use red for the Inner Core, orange for the Outer Core, yellow for the Lower Mantle, green for the Upper Mantle, and blue for the Crust. (This diagram is not drawn to scale.)



A Slice Through Earth

Use colored pencils to color in the diagram as indicated and label the names of the zones.



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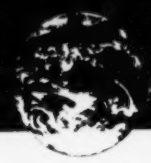


Volcanoes

The activity "Where Are the World's Volcanoes?" introduces students to the different types of volcanoes. Students enter the locations of a wide range of volcanoes on a world map. In doing so, they discover the Ring of Fire. The pattern will also reveal a connection to plate tectonics. Later, students will add a list of earthquakes to this map and draw some further conclusions.

Activity: A Map of Volcanoes Around the World

Photocopy "World Map" (in the envelope), a blank map that shows longitude and latitude. Students will also need copies of the following Activity Sheets and Information Sheets:

- "Where Are the World's Volcanoes?"
- "Three Major Types of Volcanoes"
- "Volcanoes of Note"
- "Plate Movement"
- "Major Plates of the World" (see page 38)

Review or teach students how to use longitude and latitude to locate places on a global map.

Begin to discuss the formation of mountains and volcanoes. Define **convergent**, **divergent**, and **transform** movements. Refer to diagrams on the Activity Sheet "Plate Movement" that illustrate divergent (spreading) movement, convergent (collision) movement, and transform (lateral) fault movement.

Have the students locate the listed volcanoes on the world map. You may choose to use a color key for the letters indicating the three kinds of volcanoes.

When students have completed their maps and the Ring of Fire has appeared, point it out and show students the world map on the National Geographic Society poster "The Earth's Fractured Surface" (in the envelope).

Help students draw inferences about the origin of mountains and volcanoes through discussion and study of the plate tectonic diagrams. You may first want to encourage small group brainstorming sessions.

The class may then wish to research some examples of each type of volcano in geology or earth science texts.

Volcanoes and the Environment

The two largest volcanic eruptions in recent history occurred in Indonesia: Tambora, in 1815, and Krakatau, in 1883. The violent explosion and collapse of rocks after the Krakatau eruption caused a seismic sea wave, called a **tsunami**, which devastated the surrounding islands, killing more than 25,000 people.

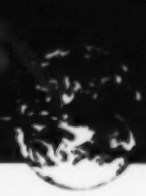
Have the students research how tsunamis are generated. Discuss the environmental effect of these waves. Tsunamis are not tidal waves because they are not related to tides.

Ask students why the most violent eruptions in recent history have occurred in Indonesia and not, for example, in Hawaii or Iceland. What is the difference between the Indonesian and Hawaiian volcanoes? Looking at the map of the world with the volcano types plotted on it, students should try to predict where violent eruptions will occur. They may choose to keep track of any volcanic eruptions that occur throughout the year to see if their predictions are correct.

Extensions

1. Have students read newspaper or magazine articles associated with each of the volcano types—for example, Paricutin in Mexico (cinder cone), Kilauea in Hawaii (shield), and Mount St. Helens in Washington (composite), and Tambora in Indonesia (caldera). Students should take notes and make a chart comparing the types of hazards created by the eruption, the greatest distance from the volcano that was affected by the eruption, the number of people killed by the volcano, the explosiveness of the eruption, and the duration of the eruption. Include which type of eruption is the most dangerous and which type of eruption causes damage over the greatest distance.

2. Have students brainstorm a list of responses to the question: how do volcanoes benefit humans? Point out that many people live in volcanic regions. What advantage do they find in living in such hazardous areas? After students brainstorm ideas, have them write to the tourist bureaus of countries in volcanic regions to see if their ideas are mentioned in the literature. What reasons are mentioned that they did not think of? Students can choose places from



their world map of volcanoes–Japan, northwestern United States, Indonesia, Iceland, and Hawaii. Do any of these advantages benefit the students' community?

3. Take a field trip and look for buildings and roads made with volcanic materials.

Suggested Resources

Dvorak, John J., Johnson, Carl, and Tilling, Robert I. (1992, August). Dynamics of Kilauea Volcano. *Scientific American, 267* (2), 46–53.

Grove, Noel. (1992, December). Volcanoes: Crucibles of Creation. *National Geographic, 182* (6), 3–41.

McDowell, Bart. (1986, May). Eruption in Colombia. *National Geographic, 169* (5), 640–653.

Three Major Types of Volcanoes

EVENT	CINDER	SHIELD	COMPOSITE OR STRATO
Height	30 to 500m 100 to 1,500 feet	1.5 to 10km 5,000 to 30,000 feet	300m to 5km 1,000 to 20,000 feet
Width of the Base	1 to 4 km 1/2 to 2 miles	15 to 1800 km 10 to 1000 miles	3 to 15 km 2 to 10 miles
Type of Eruption or Eruptions	Explosive, much gas	Usually quiet lava flows	Both types
Composition (aa and pahoihoi)	Pyroclastic materials flows	Lava flows	Pyroclastic and lava
Angle of Sides	10° to 45°	12° to 20°	30° to 50° steeper near the top
Typical Shape of Sides (concave or convex)	Straight to concave	Convex	Concave at top
Special Features	Big crater for size of cone	Summit caldera, lava fountains	Nuee ardente (pyroclastic flows) dangerous
Examples	Paricutin in Mexico Sunset Crater in AZ	Mauna Loa, Kilauea HI	Mount St. Helens in the US Vesuvius and Etna in Italy Fujiyama in Japan
Environmental Effects	Damaged buildings	Lava engulfs forests and farms	Mudflows Pyroclastic surges
Drawing of volcano			

Where Are the World's Volcanoes?

Cinder cone, Central Cone, Newberry Crater, central Oregon.

You will create your own map of some major volcanoes that have erupted in different parts of the world.

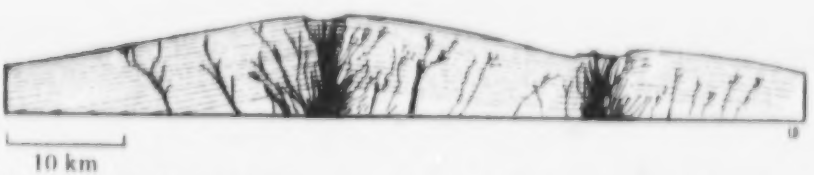
You will need the following:

- "World Map" (a blank map with latitude and longitude markings included in envelope)
- "Volcanoes of Note" (a list of volcanoes in envelope)

About Volcanoes

1. Refer to the Information Sheet "Three Major Types of Volcanoes" and define the three types of volcanoes: **cinder cone** (or pyroclastic), **composite** (or strato), and **shield**. (A **caldera** is a very large crater formed when a volcano explodes, then falls in. Calderas often form in composite or shield volcanoes.) The definitions should include the average diameter, height, and composition (lava or pyroclastic material). Note whether eruptions have been quiet lava flows, an explosive burst, or a mixture of quiet lava flows and explosive bursts. Cinder cones are small pyroclastic volcanoes, sometimes associated with shield volcanoes. Their explosiveness mimics on a small scale the devastating eruptive force of caldera eruptions, which are relatively rare.

Composite volcano (stratovolcano), Mount St. Helens, Washington, before the 1980 eruption that blew off its top.



Shield volcanoes. Sectional view of Kilauea (right) and Mauna Loa, two volcanoes on the island of Hawaii, showing magma chambers (black areas below summit calderas) and dikes that feed lava to the surface.

2. Examine the Activity Sheet "Plate Movement." Are different types of volcanoes associated with different plate tectonic situations?

A Map of Volcanoes Around the World

1. Using the list "Volcanoes of Note," plot the number of each volcano on the "World Map." Use a "c" for cinder, "s" for shield, and "t" for composite.
2. What relation do you see between plates and the location of all of the volcanoes?
3. What relation do you see between the locations of each of the three types of volcanoes and the plates?
4. Why do you think there are zones or belts of volcanoes?
5. Why do you think the boundary of the Pacific Ocean is called the "Ring of Fire"?
6. Find out what effect volcanic eruptions have on the global environment. (Hint: Look up Krakatau, Pinatubo, El Chichon, Santorini, and Tambora.)
7. Find out how volcanic eruptions affect the local environment. (Hint: Look up Mount Pelee, Vesuvius, Ruiz, Mount St. Helens, and Paricutin.)
8. Find out how explosive volcanic eruptions in the Aleutian islands off the Alaskan coast and in Indonesia have affected airplanes traveling to Asia.
9. Why do you think so many people live near major volcanic areas in countries like Indonesia, Japan, Columbia, and Italy?

Earthquakes

Students will learn about earthquakes, then add locations of earthquakes to their "World Map" (included in envelope).

Activity: "What Happens in an Earthquake?"

Distribute the following:

- Activity Sheet "What Happens in an Earthquake?"
- Information Sheet "Coalinga School Report"
- Films, photographs, and other visual aids that show earthquake damage

Conduct a class discussion about basic earthquake terminology. Use the diagram in the Activity Sheet "What Happens in an Earthquake?" as an aid, and define for students the following terms: **earthquake**, **focus**, **epicenter**, **fault**, **earthquake waves**, and **fault scarp**.

Earthquakes often cause land to rise, in some cases creating new land in areas formerly covered by water.

Faults that cut the surface often produce steep slopes called fault scarps. Indicate the displaced (offset) rocks and soil shown on the worksheet.

To provide examples of land created by earthquakes, discuss some fault-block mountains like the Grand Tetons, Sierra Nevada, and others, and some continental rift areas like the East African Rift valley, and the New Madrid rift zone along the Mississippi River.

Earthquakes are natural events caused by the movements of rocks in the lithosphere, which release enormous amounts of stored energy, producing rapid shaking of the ground. The waves of energy that move away from the epicenter are called **seismic** or **earthquake waves**.

The place where an earthquake originates is called the **focus** (plural **foci**). The point on Earth's surface directly above the focus is called the **epicenter**. Most earthquakes are produced by movements of rocks along faults. A **fault** is a crack along which there has been displacement of rocks. Quite often this displacement is seen in the overlying soils.

Using films, slides, other visuals, personal experience, materials from the Federal Emergency Management Agency, or the "Coalinga Schools Report," discuss what

happens during an earthquake and the amount of environmental damage that results. No area is entirely free of earthquakes, although there are areas where earthquakes are rare.

Repeated uplift along a fault or series of faults builds mountain ranges.

Gradually, over time, earthquakes change landscapes by producing new oceans (the Red Sea, Gulf of California), mountain ranges (Alps, Himalayas), and rift valleys (East Africa), and by moving enormous slabs of land (western California, Arabian Peninsula).

Activity: A Map of Earthquakes

Students will be adding earthquakes to the maps on which they plotted the volcanoes. In addition, they will need:

- Activity Sheet "Where Are the World's Earthquakes?"
- Information Sheet "Table of Earthquakes"
- Drawing paper
- National Geographic Society poster "The Earth's Fractured Surface" (in the envelope)

"Table of Earthquakes" is a list of earthquake epicenters. The earthquakes should be marked using a color different from the ones used for volcanoes. Instead of the list of earthquake epicenters, you may use earthquake locations reported in newspapers, on-line services, or government publications. The plotted points of the earthquakes may also be color coded by focal depth and magnitude, if known.

During the analysis, note that midocean ridges and trenches are visible on the satellite image "The Living Earth" (in the envelope).

To conclude, discuss the difficulties of predicting earthquakes and the somewhat greater predictability of volcano eruptions.

Extensions

1.Have students brainstorm factors that might determine the amount of damage caused by an earthquake. Ask them whether they think the magnitude of an earthquake alone determines the amount of damage. Ask students to read articles on recent earthquakes of varying magnitude and

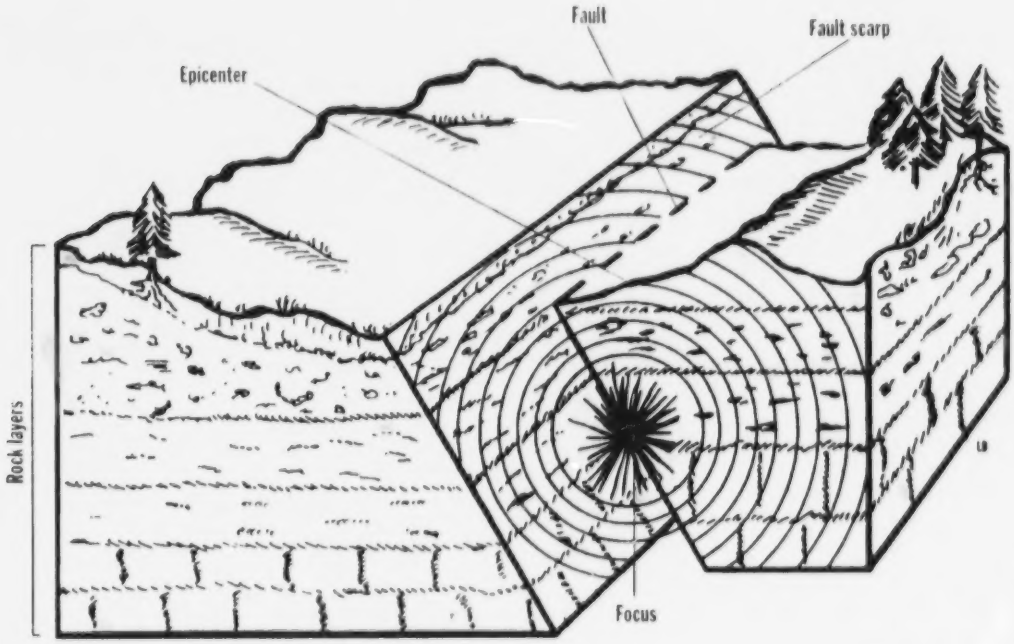
have them compare the magnitude, focal depth, distance of the epicenter from population centers, duration of the earthquake, time of day, and types of building construction. Compare these with the types and amount of damage, injuries, and fatalities. Include pairs of earthquakes where the more damaging one was of lower magnitude. For example, compare the Soviet Armenia earthquake with the recent San Francisco or Kobe, Japan, earthquake.

2. Have students design and construct "buildings" that they think will withstand an "earthquake" (the shaking of the table) and remain standing. Compare their designs with those used in earthquake-prone areas like California and Japan.

Suggested Resources

Bolt, Bruce A. (1993). *Earthquakes—Newly Revised and Expanded.* W.H. Freeman and Co., San Francisco.
Boraiko, Allen A. (1986, May). Earthquake in Mexico. *National Geographic, 169* (5), 654–675.
Canby, Thomas Y. (1990, May). Earthquake—Prelude to the Big One? *National Geographic, 177* (5), 76–105.
Gore, Rick. (1995, April). Living with California's faults. *National Geographic, 187* (4), 2–35.
Miller, Eric. (1993, November). Whose Fault Is It? A hands-on approach to seismology. *The Science Teacher, 60* (8), 28–33.

What Happens in an Earthquake?

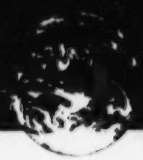


Write a definition of each term:

1. Earthquake
2. Focus
3. Epicenter
4. Fault
5. Earthquake waves
6. Fault scarp (cliff)

Questions

1. What differences in damage would you expect from a deep-focus and a shallow-focus earthquake?
2. What damage might occur if the epicenter is in a rural area? in a city?
3. If roads, railroads, or pipelines cross the fault, what will happen to them when a scarp forms during an earthquake?
4. Why do you think earthquake damage is usually less severe in places farther from the epicenter?
5. Why should you be prepared for earthquakes even if you live in an area where earthquakes are rare?
6. In what ways do you think people are likely to get hurt in earthquakes?



Coalinga Schools Report

At 4:42 p.m. on Monday, May 2, 1983, an earthquake registering 6.5 on the Richter scale struck the Coalinga area. Seconds later there was an aftershock of 5.0 Richter magnitude.

Coalinga has three elementary schools, one junior high, and one high school, serving approximately 1,900 students. The school buildings were constructed between 1939 and 1955. They contain 75 classrooms, plus gymnasiums, auditoriums, libraries, and multipurpose rooms.

Superintendent Terrell believes that death and serious injury would have occurred if school had been in session. The following is an account of the nonstructural damage to these schools:

Windows
Large windows received and caused the most damage. The 31-year-old junior high library had glass windows approximately 2.40 m x 3.04 m (8 x 10 ft) on the north and south walls. The glass was not tempered. All the windows imploded and littered the room with dagger-shaped pieces of glass. Floor tiles and wooden furniture were gouged by flying splinters.

Lighting Fixtures
Approximately 1,000 fluorescent bulbs fell from their fixtures and broke. All of the fixtures in the elementary schools came down, and many in other buildings. None of the hanging fixtures had safety chains. Glass in the older recessed fixtures was shaken out and broken.

Ceilings
Improperly installed T-bar ceilings came down. Glued ceiling tiles also fell, especially around vent ducting and cutouts for light fixtures.
Basements and Electrical Supply Water pipes which came into the buildings through concrete walls were severed by the movement of the walls. Basements were flooded to five feet.
Since all the electrical supply and switching mechanisms for these buildings were in the basements, all of them were destroyed by water.

Chemical Spills
In the second-floor high school chemistry lab, bottles of sulfuric acid and other chemicals stored in open cabinets overturned and broke. Acid burned through to the first floor. Cupboard doors sprang open and glass cabinet doors broke, allowing chemicals to spill. Because there was no electric ventilation, toxic fumes permeated the building.

Furnishings and Miscellaneous Items
File cabinets flew across rooms; freestanding bookcases, cupboards, cabinets, and shelves fell over.

Machine shop lathes and presses fell over.

Typewriters flew through the air.

Metal animal cages and supplies stored on top of seven-foot cabinets crashed to the floor.

Movie screens and maps became projectiles.

Storage cabinets in the high school had been fastened to the wall with moli bolts, but they were not attached to studs. They pulled out of the wall and fell to the floor with their contents.

(based on a report prepared by E. Robert Bulman for Charles S. Terrell, Jr., superintendent of schools for San Bernardino County, California) Reprinted from *Earthquakes* (1988). National Science Teachers Association, Arlington, VA and Federal Emergency Management Administration.

Where Are the World's Earthquakes?

You will now add earthquakes to your map of the world. You will need

- "World Map" (your world map with volcanoes added)
- "Table of Earthquakes" (a list of earthquakes)
- A world map or globe that shows topography both above and below sea level
- A map that shows the tectonic features of the world

A Map of Earthquakes Around the World

1. Plot each earthquake epicenter on your "World Map" using longitude and latitude. Print a small, legible, corresponding number at each epicenter.
2. What relation do you notice between epicenter locations and mountains, continental margins, island arcs, oceanic trenches, faults, midocean ridges, and other geologic features?
3. How do the locations of most epicenters relate to the boundaries of tectonic plates?
4. Why is there a relation between epicenter locations and plate boundaries?
5. What relation do you see between the epicenters and volcanoes?
6. Why do you think this relation exists?
7. What damage to human property and life have you heard about from earthquakes in California, Alaska, China, Japan, Mexico, or Italy?

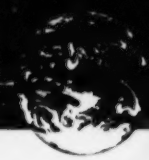


Plate Tectonics

Earth's surface and Earth's interior are in constant motion. Earth's interior is heated by the decay of radioactive materials and friction generated by the pull of gravity on the huge plates. Scientists think the movement of plates is driven by large convection cells.

The convection cells move slabs of the lithosphere, called plates, across Earth's surface. Although compared to a human time span these forces are generally very slow, they are very powerful. This process, called **plate tectonics**, has had a profound effect on Earth's environment, building continents and mountain ranges, and causing earthquakes and volcanoes. Do other planets show evidence of plate tectonics?

Demonstration: Convection Currents

This demonstration shows diverging convection currents. Opposing currents will be formed in the two adjacent beakers.

Materials

- 2 beakers
- Bunsen burner
- 2 ring stands with ring clamps
- 2 wire mesh plates to hold the beakers
- Paper holes punched from paper
- Pencil shavings
- Water
- Safety goggles

Procedure

1. Set up the ring stands and ring clamps to hold the wire mesh plates above the Bunsen burner.
2. Place each beaker on a wire mesh plate.
3. Set these ring stands 1 inch apart.
4. Place the Bunsen burner between the two ring stands.
5. Fill each beaker 3/4 full of water. Add punched holes and pencil shavings and stir.
6. Light the Bunsen burner. The flame should be between the two beakers, so it only heats one side of each beaker. (The flame can lap up the side of each beaker.)

Plate Tectonics

Earth's lithosphere consists of plates that move slowly across its surface. The Information Sheet "Major Plates of the World," used in several activities, shows seven major plates and several minor ones.

Activity and Discussion: Plate Tectonics

Distribute the Activity Sheet "Plate Movement" (page 37) and have students study the diagram of the major types of plate motion, then make drawings of the three shown:
divergent plates: constructive plate margins, where oceanic lithosphere is formed
convergent plates: destructive margins, where the lithosphere is consumed
transform faults: faults where plates move past each other laterally.

When plates converge, the denser plate often sinks or "subducts" into the lithosphere. Subduction creates great pressure and heat, causing the rocks to melt, forming magma that then rises to the surface in volcanic eruptions.

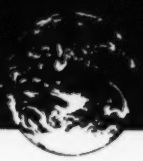
When plates diverge, rift valleys are created. As the plates move away from each other, the pressure on the underlying magma is relieved and it rises through the rift valley. These rift valleys are found at the midocean ridges (in, for example, the Atlantic Ocean) and on continents (for example, East Africa.)

Forces That Alter Earth's Surface

You may choose to use the following device to gain the students' attention. It separates the forces that are active on Earth's surface and subsurface into two artificial categories.

A "constructional" force is one that builds land up relative to sea level and a "destructional" force is one that erodes, abrades, or destroys land. Students should be told that this is not a true classification for forces, but it is an effective way to remember them.

Conduct a class discussion on the "constructional" and "destructional" forces that affect Earth's surface. List some specific examples. Discuss how forces that are constructional for Earth can be destructive to human



beings. Indicate to students that there also can be constructional aspects of destructional forces.

Have the students study the Information Sheet "Forces at Work." This generalized plate tectonics diagram includes many forces. Students should identify and classify them. Then they should discuss the sources of energy for each force.

Erosional forces, such as moving water and wind, driven by gravity or solar energy, abrade surfaces and shift rock material to lower elevations. (See Land unit.) Ask students to find examples of deltas, alluvial plains, deltas below sea level, flood plains, sand dunes, and terminal moraines, where erosive forces have deposited materials. Conduct a class discussion on other forces that alter Earth's surface. Give some specific examples.

Which cause uplifting and which cause levelling?

Where are the energy sources for these forces?

How Do Mountains and Volcanoes Form?

Let the students study the National Geographic Society poster "The Earth's Fractured Surface" (in the envelope), which shows many of the forces at work on Earth's surface and in its interior.

Draw inferences about the origin of mountains and volcanoes by studying the plate tectonics diagrams in the course of a class discussion. This may be a good opportunity to hold small group brainstorming sessions before having a discussion with the whole class.

Have the students locate examples of mountains on the poster. On the "Forces at Work" diagram, try to locate where these mountains might form.

Note again that midocean ridges and trenches are visible on the satellite image "The Living Earth" (also in the envelope).

Activity: Plate Puzzle

Distribute photocopies of the Activity Sheets "Major Plates of the World," "Plate Puzzle," "Puzzle Pieces 1" and "Puzzle Pieces 2." Students will also need a set of 12 colored pencils. Use the color key provided or help the students choose their own color code for the list of plate names. Choose colors that will provide contrast in the completed puzzle. Because there are 12 pencils in most sets, but 14 listed names, you should use light and dark shading for two colors, or add stripes or dots.

To help show the relationship between plate boundaries and volcanoes, you may wish to crack a raw egg and show students how the liquid escapes along the cracks.

Extension

Provide students with a world map, a ruler, and a calculator. Tell the students to assume that the plates move about 3 cm per year. Have students calculate how long it will take, if the motion continues at the same rate, for San Francisco and Los Angeles to become the same city. Ask how long ago do they think Africa and South America split apart. What might have been the differences in the climate when these two continents were joined to form one large continent?

Suggested Resources

Bonatti, Enrice. (1994, March). The Earth's Mantle below the Oceans. *Scientific American, 270* (3), 44–51.

Editor. (1986, May). When the Earth Moves. *National Geographic, 169* (5), 638–639.

Murphy, J. Brendan, and Nance, R. Damian. (1992, April). Mountain Belts and the Supercontinent Cycle. *Scientific American, 266* (4), 84–91.

Powell, Corey S. (1991, June). Peering Inward. *Scientific American, 264* (6), 100–111.

Stager, Curt. (1990, May). Africa's Great Rift Valley. *National Geographic, 177* (5), 2–41.

— (1995, March). Earth on the Move. *Science and Children, 32* (6), 4-page insert.

INFORMATION SHEET : PLANET
PLATE TECTONICS

Forces at Work

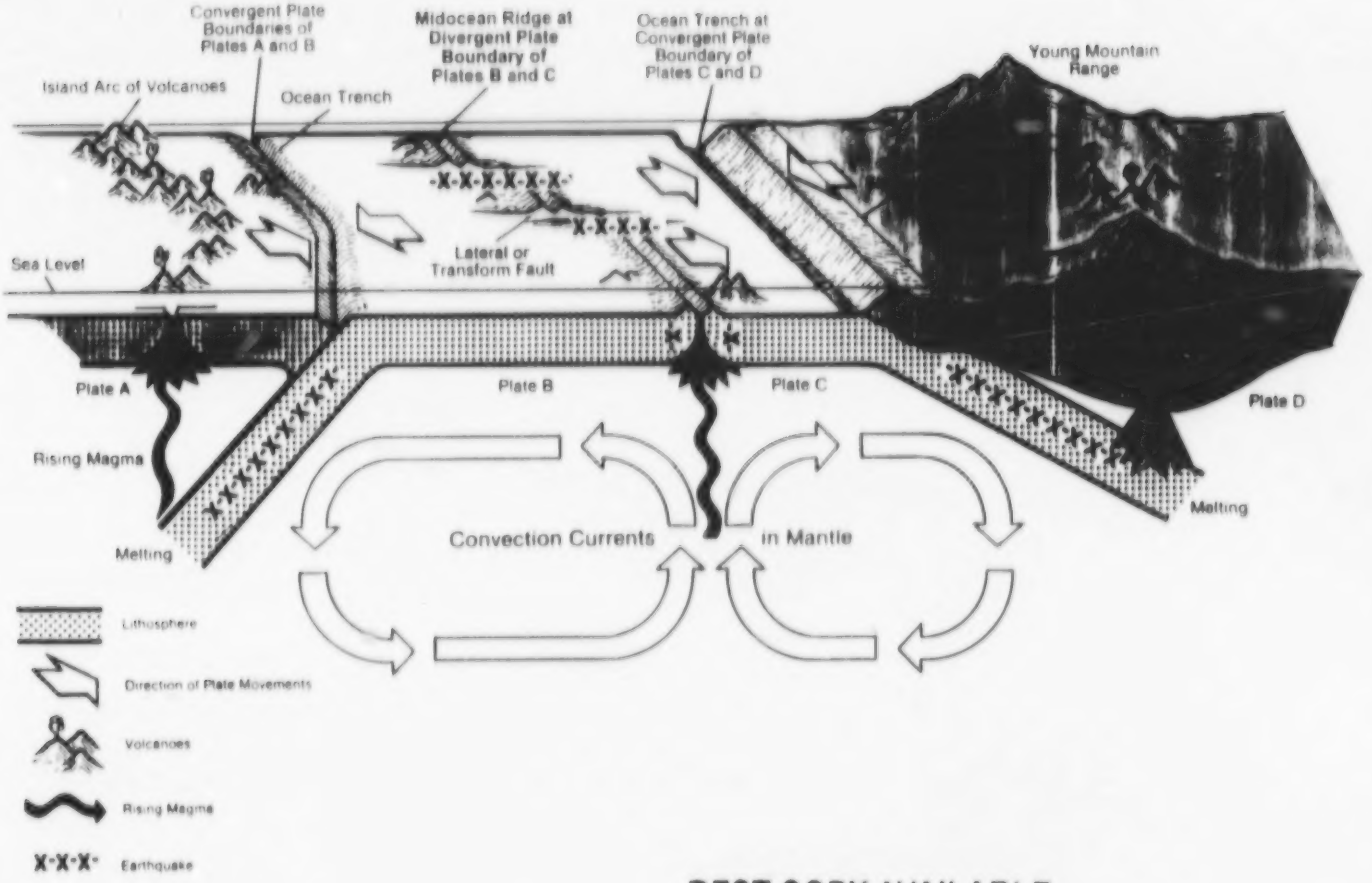


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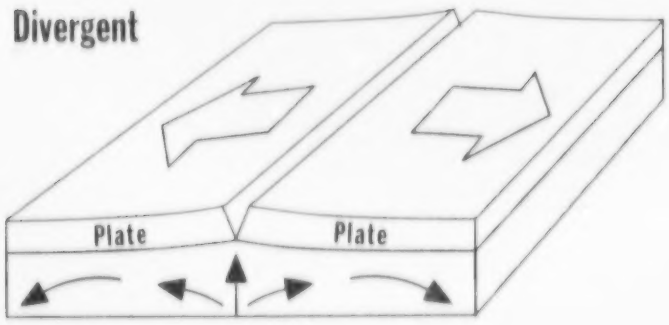
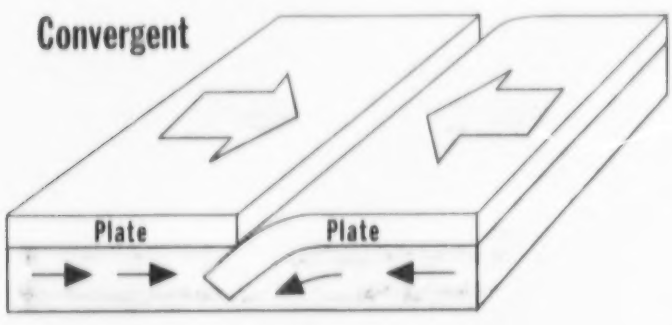
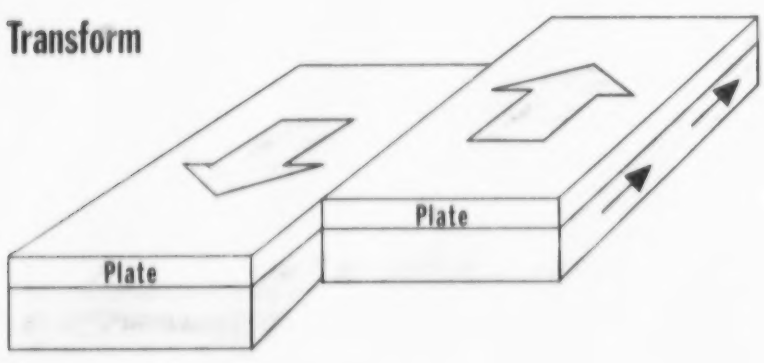
Plate Movement







Earth's plates move in three ways. Plates may diverge or converge, or they may slide past each other as a transform. Grey arrows show plate motion. Black arrows show motion of convection currents in Earth's mantle.

INFORMATION SHEET : PLANET
PLATE TECTONICS

Major Plates of the World

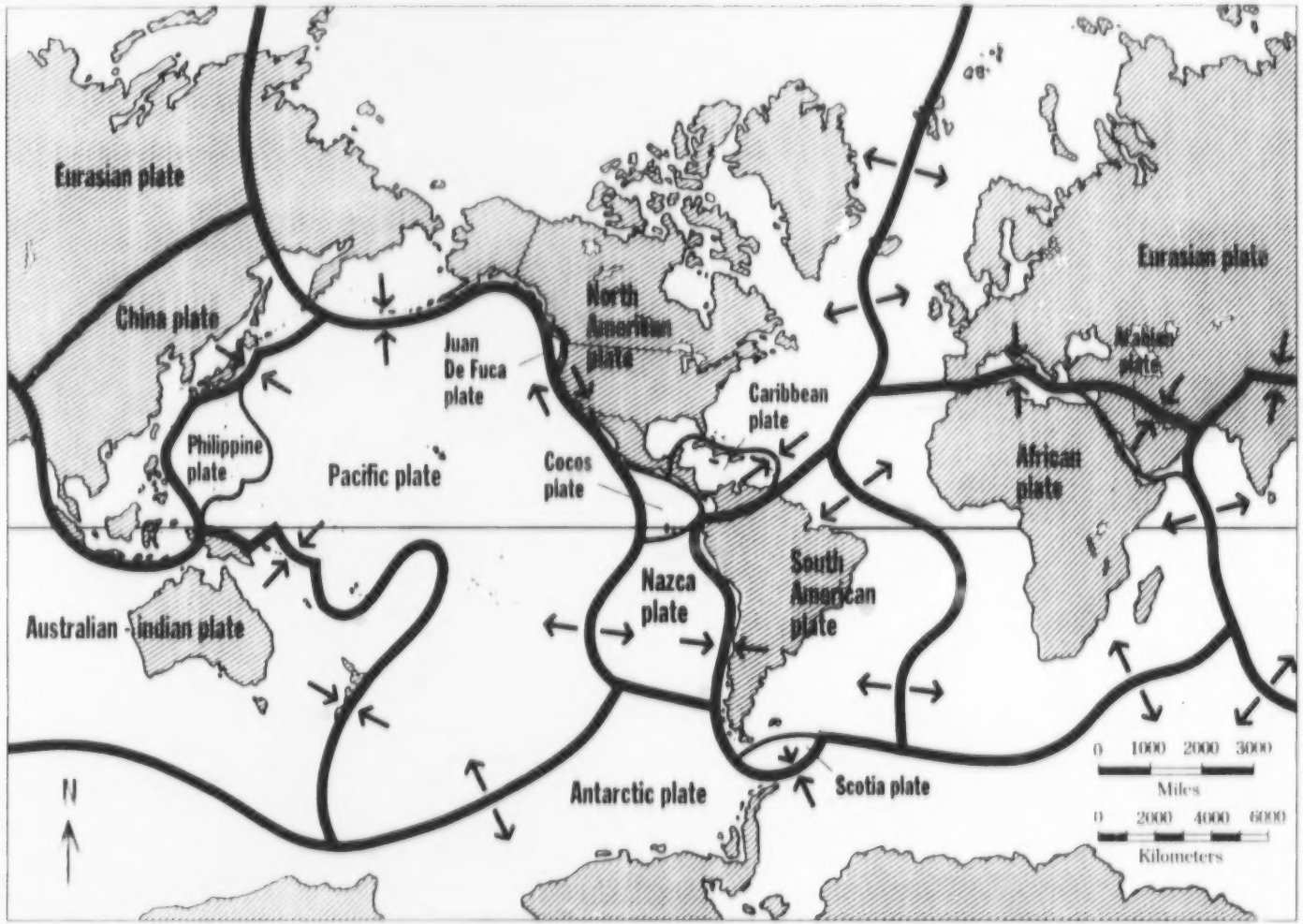


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Plate Puzzle

You will become familiar with the names and locations of all of the major plates of Earth's lithosphere and some of the minor ones. Notice that some of these plates carry the same names as continents, oceans, or other geographic features, but they do NOT have the same boundaries.

Materials:

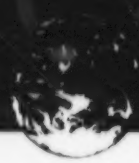
- A set of 12 colored pencils
- Scissors
- Glue or glue stick
- Activity Sheets "Puzzle Page 1" and "Puzzle Page 2"
- Information Sheet "Major Plates of the World"
- 8 1/2" x 11" sheet of white paper

Procedure:

Together with your class, decide on a color scheme for the following 14 categories.

Plate Names and Suggested Code
1. Australian-Indian = dark green
2. Caribbean = light green
3. African = red
4. Antarctic = dark blue
5. Pacific = light blue
6. Arabian = dark brown
7. North American = orange
8. Philippine = light brown
9. Eurasian (and China) = gray
10. Nazca = yellow
11. Scotia = pink
12. Juan De Fuca = purple
13. South American = gray stripes
14. Cocos = purple stripes

1. Using the completed puzzle, "Major Plates of the World," as a guide, write the names of the 14 plates on "Puzzle Page 1" and "Puzzle Page 2." Use arrows to label the smallest plates. Set the completed puzzle aside.
2. Shade in the 14 plates on the puzzle pieces, using the agreed-on colors.

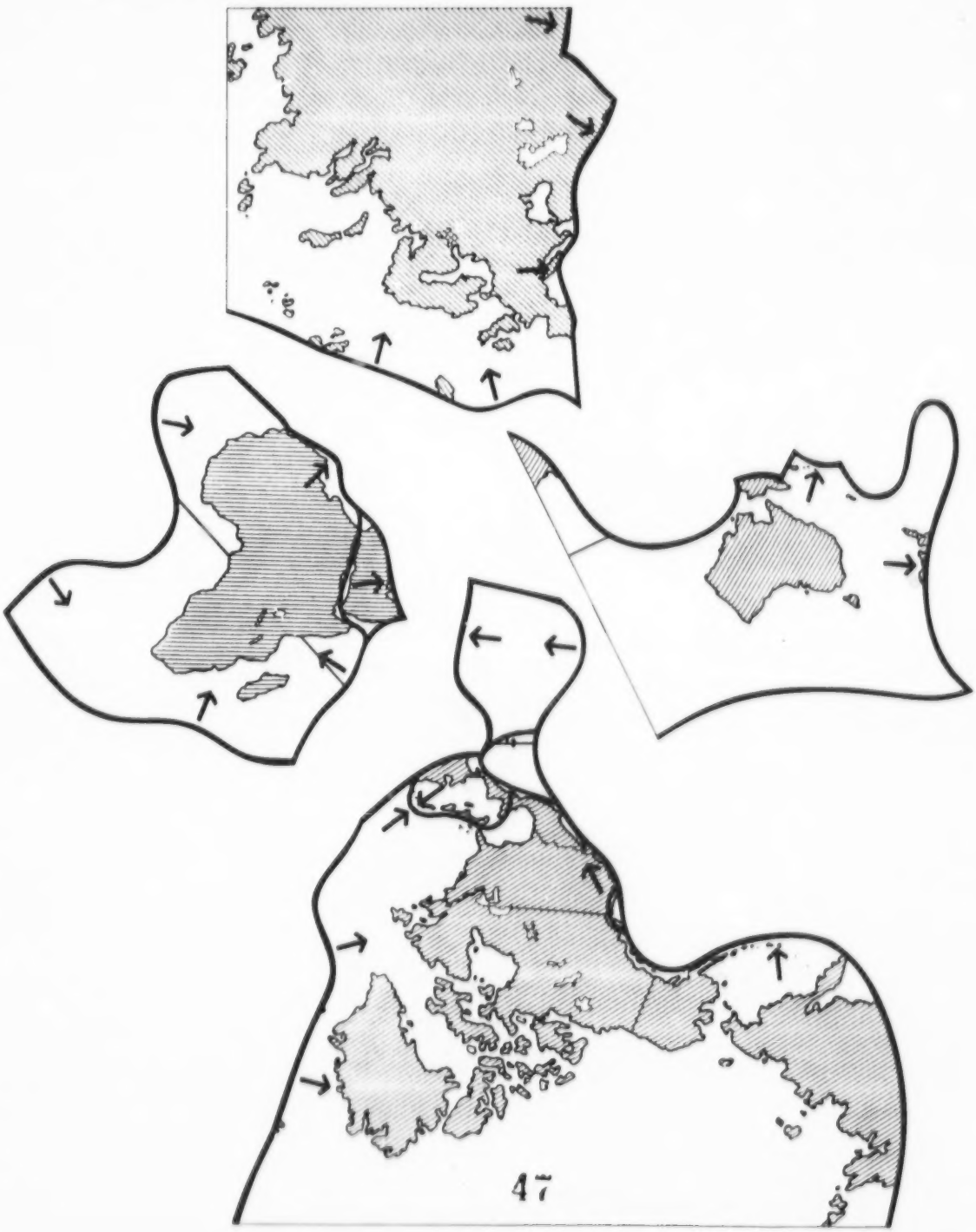


3. Using scissors, cut out each of the plates from "Puzzle Page 1" and "Puzzle Page 2."
4. Arrange the cutouts in their correct positions on the blank sheet of paper and then fix them in place with glue.

Questions:

1. Which plate(s) are almost totally in an ocean?
2. Which plate(s) are almost totally on land?
3. Which is the largest plate?
4. Which two plates are on opposite sides of the San Andreas Fault?
5. Which plate is being subducted under Oregon and Washington?
6. What are two plates that are moving away from each other?
7. What are two plates that are moving towards each other?
8. What are two plates that are moving past each other?

Puzzle Pieces 1



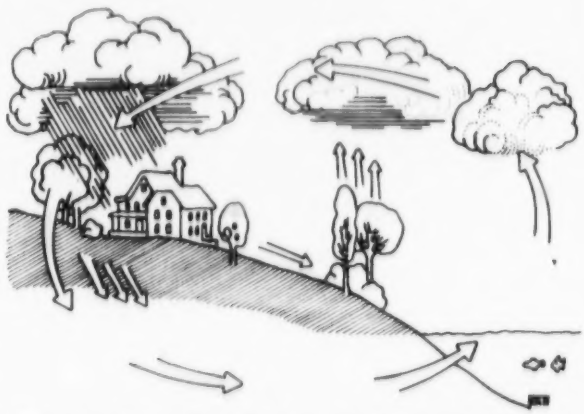
Puzzle Pieces 2

Life on Earth

Earth is unique among the planets in its ability to support life. Students will discuss what makes life possible on Earth, then begin to think about ways the delicate balances that make life possible may be threatened by human activities.

Activity: Uniqueness of Earth in the Solar System

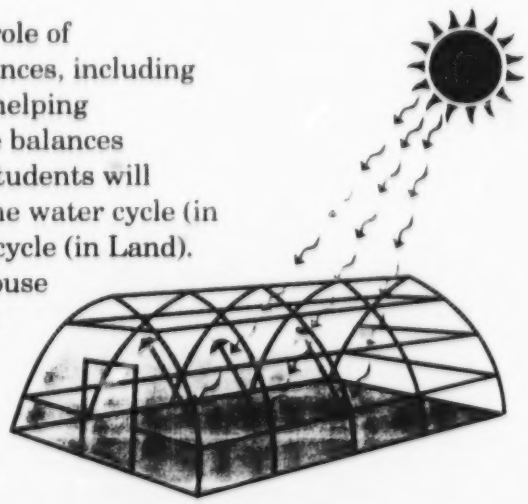
Have students compare Earth to other planets and determine what makes it unique. Students may research the distances of the planets from the Sun, the composition of their atmospheres, and other factors. Ask which characteristics of Earth contribute to its ability to support life. (Answers may include temperature or climate, the nature and composition of the atmosphere, amount of water, and, less obviously, Earth's rotation and plate tectonics.) Students may suggest specific roles of the oceans and atmosphere. Students may also wish to discuss whether life is possible elsewhere in the Universe.



The water cycle. Arrows show water movement as it evaporates from the ocean and vegetation (right), passes through the atmosphere as water vapor, condenses in clouds and falls as precipitation (left) on vegetation and Earth's surface. Then it runs off as surface water or infiltrates soil to become groundwater and returns to the ocean.

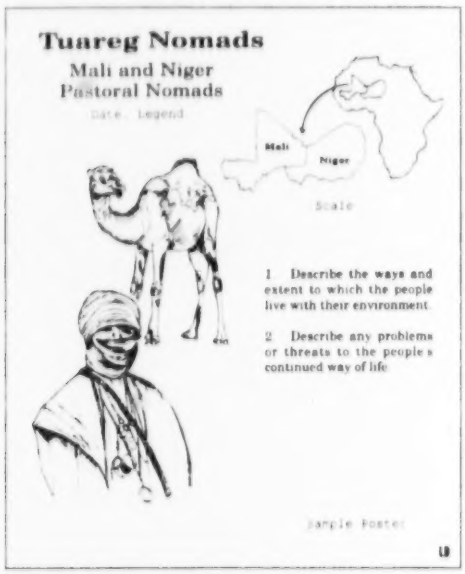
Discussion: Cycles and Balances

Follow through with a discussion of the role of atmosphere in maintaining cycles and balances, including temperature. Even the ocean currents, by helping redistribute heat, contribute to the delicate balances necessary to maintain conditions for life. Students will learn about specific cycles in other units: the water cycle (in Water), the carbon cycle (in Life), the rock cycle (in Land). Balances include temperature (the greenhouse effect, which is studied in the Air unit), the



The greenhouse effect. Short wavelengths of visible light pass easily through glass. Long infrared "heat" rays are trapped inside the greennouse.

ozone layer (also in the Air unit), and ecosystems (studied in the Life and Water units). Requirements for survival and limiting factors are studied in the People unit.


Tuareg Nomads
Mali and Niger
Pastoral Nomads
Mali
Niger
1. Describe the ways and extent to which the people live with their environment.
2. Describe any problems or threats to the people's continued way of life.

The Tuareg people of the central Sahara Desert, in northwestern Africa. They are nomads who herd cattle and other domestic animals in areas near the desert. Damage to vegetation by the herds results in topsoil loss and invasion by the desert (desertification).

Ask students to think of some current threats to Earth's cycles and balances caused by human activity. Ask why and how they are problems, as a preliminary to later study of pollution, habitat destruction, and other issues.

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Where Do Plants and Animals Live?

Students now understand better Earth's space environment and internal processes. These factors produced Earth's atmosphere, which permits life to exist. To understand our environment, we need to understand why plants and animals live where they do. We know much more about living on land than in the ocean; Project 2 focuses on land regions.

What Makes Climate?

Earth forces control the movement of tectonic plates, which governs the location of continents and distribution of mountains. Ocean currents flow around continents; air currents (winds) flow over mountains. (See map of global wind belts in the Air unit.)

These flows, plus seasonal changes related to latitude, control the combinations of temperature and precipitation that mark different climates. Different climates, different geographic factors like elevation and latitude, and different geologic factors like soils and bedrock produce regions characterized by groups of plants and animals.

How Do We Describe Different Regions?

Earth can be divided into large regions called biogeographic realms. A **realm** has climatic and topographic boundaries that plants and animals find very hard to cross, so a realm has a unique set of living things. For example, the Nearctic realm, which is North America as far south as the Tropic of Cancer, in central Mexico, has animals like skunks, muskrats, turkeys, and bison. (You can see the Nearctic realm on the Physical Map of the Americas, on the back of the poster "Bird Migration in the Americas," in the envelope.)

Realms are made up of smaller areas called biomes. A **biome** is named for its vegetation—tundra, coniferous forest, temperate deciduous forest, tropical forest, desert, grassland, and so on. A biome has its own combination of plants and animals. In the Nearctic realm, the tundra biome lies south of permanent snow and ice. South of the

tundra, the coniferous forest crosses the continent from Pacific Ocean to Atlantic Ocean. South of the coniferous forest, mountain barriers create several biomes: temperate rain forest along the Pacific coast, desert, pockets of coniferous forest, grassland, and temperate deciduous forest in the East.

Biomes are made of a mosaic of different combinations of living things specific to a particular situation, of communities of plants and associated animals in their habitats. (The animals depend on the plants for food.) For example, plants on south-facing slopes in the temperate deciduous forests of Maryland are different from plants on north-facing slopes. Plants growing on shale bedrock are different from those growing on limestone. Combinations of streams and wetlands, kinds of rock and soil, elevation (the higher the elevation, the lower the temperature), latitude (the farther north, the lower the temperature), and seasonal differences create the great variety of communities of living things and their habitats.

The biome in this picture is the coniferous forest, the band of evergreen trees that stretches across northern United States and southern Canada.

People have divided biomes in different ways to help describe communities and habitats. For example, the Forest Service of the U.S. Department of Agriculture divides the 50 states into four ecoregions and a total of 31 ecological provinces (*Descriptions of the Ecoregions of the United States*, Miscellaneous Publication Number 1391, by Robert G. Bailey, 1980, Ogden, Utah, Intermountain Region, USDA Forest Service). In the USDA classification, the mountains of Maryland are in the Appalachian oak forest section of the eastern deciduous forest province of the hot continental division. (This division has hot humid summers.)

Project 2: Tour of Earth's Biomes

In this project, students create a second display. They research Earth's biomes and assemble pictures and diagrams to show where plants and animals live around the world. They arrange the pictures on classroom walls or in a school hall and write short descriptions to place beside the pictures. Descriptions should tell how the biome looks in different places and list some plants and animals that live there.

Most organisms have specific living requirements of temperature, food, water, shelter, and light, and live in a restricted area. Yet every part of Earth has something living there. Humans can live nearly everywhere on land, but tend to live between 50 degrees north latitude and 10 degrees south latitude, and are concentrated in certain areas in that zone.

The golden-cheeked warbler lives in the grassland biome of west-central Texas. It makes its nest from strips of Ashe juniper bark. When juniper trees are cut to make room for grazing land or houses, the warbler loses living space (habitat).

Organization

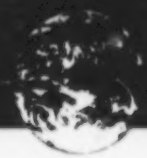
Have students work in groups. If you have a large class or are working with more than one class, you may divide biomes by continent. If resources are limited, you may confine the study to a single continent such as North America.

To expand the display, ask each group to describe an environmental problem in the biome it is researching. In tropical forests, cutting trees for lumber is rapidly destroying rain forests, for example. In several biomes, acid rain has changed the ecology. In grasslands, plowing the surface for farming has resulted in large quantities of top soil lost to wind and water erosion.

When the display is ready, ask each group to present its biome to the class. As an extension, each group might make a guidebook to its biome, with maps, pictures, and detailed information.

Researching Biomes

You will need biology and ecology books to help students learn the names and distributions of biomes. Atlases and field guides to plants and animals may be helpful. Magazines like *National Geographic*, *Nature Conservancy*,



Audubon, and *Natural History* have articles that illustrate different areas.

Travel literature has many scenes that will be useful in the display. Local travel agencies may contribute old brochures for students to use if you make advance arrangements.

Students may wish to watch biology and geography videos. Countries or regions may have several biomes, so travel videos or CD-ROMs may also be useful.

Invite people who have visited different parts of the world, including students, to show slides, prints, or videos to the class.

Teaching Notes

Touring Earth's biomes introduces students to activities and ideas they use in the other units in this series: Air, Water, Land, and People.

In each unit they work in groups to gather, organize, and analyze information. They use and make maps. They practice describing, classifying, and identifying objects, then fitting this information into a larger activity like investigating a local waterway or landscape. They learn about some issues of environmental policy and problems of environmental management.

As with the Universe project, the biome display may be a cooperative teaching effort. Working with social studies teachers, you might add cultural information.

Activity: Conducted Tours

When the display is ready, have the class form groups of tour guides. The guide groups may consist of a member from each of the groups that put up the display; then different students talk about different parts of the display. Give tours to other classes, families, scout troups working on natural history badges, and groups like the local chapter of the National Audubon Society.

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